Investigation of inelastic ^{40}Ca*(p,p')X* reaction at 1 GeV

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The polarization of the secondary protons in the inelastic (*p,p'*) reaction on the ^{40}Ca nucleus and the relative cross sections of this reaction at 1 GeV of the initial proton energy were measured in a wide range of the scattered proton momenta (**K**) at lab. angles $\Theta = 13.5^\circ$ and $\Theta = 21.0^\circ$. The final protons from the reaction were detected by means of a magnetic spectrometer equipped with multiwire - proportional chambers polarimeter.

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Abstract

The polarization of the secondary protons in the inelastic (*p,p'*) reaction on the ^{40}Ca nucleus and the relative cross sections of this reaction at 1 GeV of the initial proton energy were measured in a wide range of the scattered proton momenta (**K**) at lab. angles $\Theta = 13.5^\circ$ and $\Theta = 21.0^\circ$. The final protons from the reaction were detected by means of a magnetic spectrometer equipped with multiwire - proportional chamber polarimeter.

Close to the maximum of the *pN* quasielatic cross section peak, which is mainly determined by the (*p,pN*) reactions, a reduction of the measured polarization of the scattered protons in comparison with predictions of the Plane Wave Impulse Approximation (PWIA), based on parameters of the free elastic proton-proton and proton-neutron scatterings, was observed as in other similar experiments. A big value of the polarization obtained in the range of the scattered proton momenta is larger than those corresponding to the *pN* quasielastic peak, where a contributions from the (*p,pN*) reaction are suppressed, is related possibly to a manifestation of the cluster component of the ^{40}Ca wave function.

1 Introduction

The present work is a part of wide experimental program in the frame of which medium - induced modifications of nucleon - nucleon scattering amplitudes are studied at PNPI synchrocyclotron with 1 GeV proton beam energy[1-7]. In the exclusive (*p,2p*) experiments with different nuclei the polarization of both secondary protons have been measured and the shell structure of the investigated nuclei being clearly distinguished. In these experiments, a two-arm magnetic spectrometer having a high energy overall resolution was used. Both arms of the spectrometer were equipped with multiwire proportional chamber polarimeters.

In the present work, the high energy arm of the spectrometer was used to measure the polarization (**P**) of the secondary protons in the inelastic (inclusive) ^{40}Ca(*p,p'*)*X* reaction and the relative differential cross sections of the reaction as a function of the scattered proton momentum (**K**) at relatively small lab. angles $\Theta = 13.5^\circ$ and $\Theta = 21.0^\circ$.

The results of the experiment one assumes to use for estimation of the integral contribution from the multiple knockout collisions (multi-step processes) in the momentum region of the *pN* quasielastic peak, where the single-step (*p,pN*) knockout reactions are proposed to be dominant. Such estimations, for instance, have been done for the reaction ^{12}C(*p,p'*)*X* at 800 MeV [8]. According to this work the contribution from multi-step processes in the polarization of the scattered protons with momenta close to maximum of the *pN* quasielastic peak is not so large.

A large reduction of the analyzing power Ay (in experiments with polarized proton beam) and secondary proton polarization P in the inclusive *A(p,p')X*

reaction in the momentum range of the pN quasielastic peak relative to the corresponding values for free pN scattering was called a "relativistic signature"[9] and a significant part of the reduction is explained in the relativistic approaches [10].

2 Experimental results

The measured polarization of the scattered protons $\mathbf{P}$ in the ^{40}Ca(p,p')X reaction and relative cross sections of the reaction are presented in Fig. 1-2 (see also Tables 1-4 and Fig. 3 in Appendix). In Fig. 1-2, the solid and dashed curves are the result of polarization calculations in the plane wave impulse approximation (PWIA) proposing that the mechanism of the reaction is a single-step (p, pN) process, and using the final (FEP) and initial (IEP) energy prescriptions, respectively [11]. At given scattered proton momentum $\mathbf{K}$, averaging over the polarization in (p,p'p) and (p,p'n) scattering was performed in the range of residual nucleus momentum $\mathbf{K}_{A-1}$ up to 200 MeV/c using the current SAID phase shift analysis [12].

As is seen from Fig. 1-2, the measured polarization in the region close to maximum of the pN quasielastic peak is smaller than that predicted in the framework of the PWIA as it was observed in other similar experiments [8,10,13].

At the scattered proton momenta $|\mathbf{K}| > 1590$ MeV/c (Fig. 2), where the quasielastic A(p,p'N)A-1 processes are suppressed due to the large value of the residual nucleus momentum $|\mathbf{K}_{A-1}| > 200$ MeV/c, the other reactions can be dominant like to the ^{40}Ca(p,p'^{4}He)^{36}Ar quasielastic scattering at the momentum value $|\mathbf{K}|$ about of 1640 MeV/c. At this momentum, the value of the measured polarization in the reaction ^{40}Ca(p,p')X is close to that observed in the p^4He elastic scattering [6], If the latter observation is not accidental, it possibly means that the wave function of the ^{40}Ca nucleus contains the ^{4}He-like cluster component in the kinematics under investigation. For study in detail, it takes to perform the polarization measurements at different angles of the scattered proton in coincidence with a low energy particle knocked out from the nucleus.

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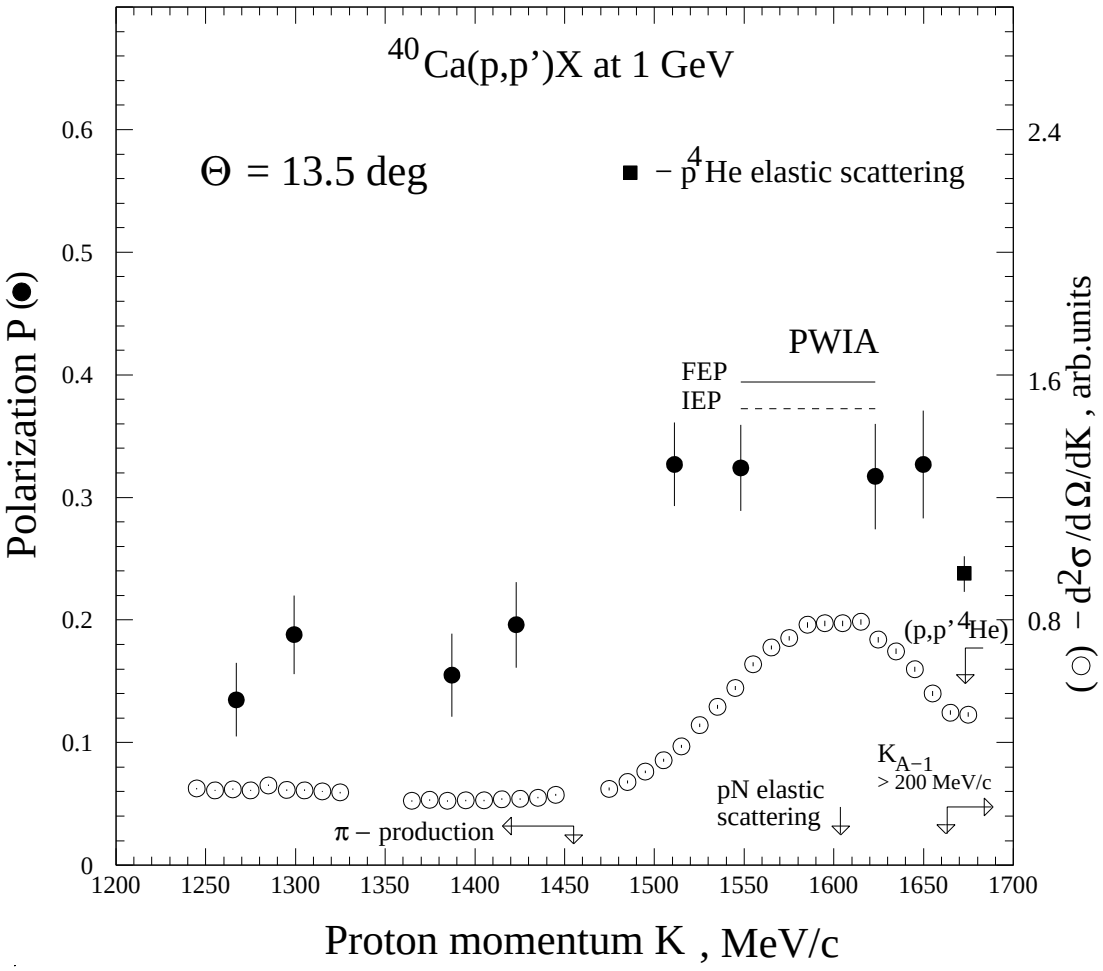

Figure 1: Polarization **P** of the protons scattered at angle $\Theta = 13.5°$ (•) in the inclusive reaction ^{40}Ca$(p,p')X$ and the relative cross section of the reaction $\frac{d^2\sigma}{d\Omega d\mathbf{K}}$ - (○) as a function of the secondary proton momentum. Solid and dashed curves (straight lines) are the result of calculation in the PWIA using the final (FEP) and initial (IEP) energy prescription, respectively. The black square corresponds to the value of polarization in the elastic p^4He scattering [14].

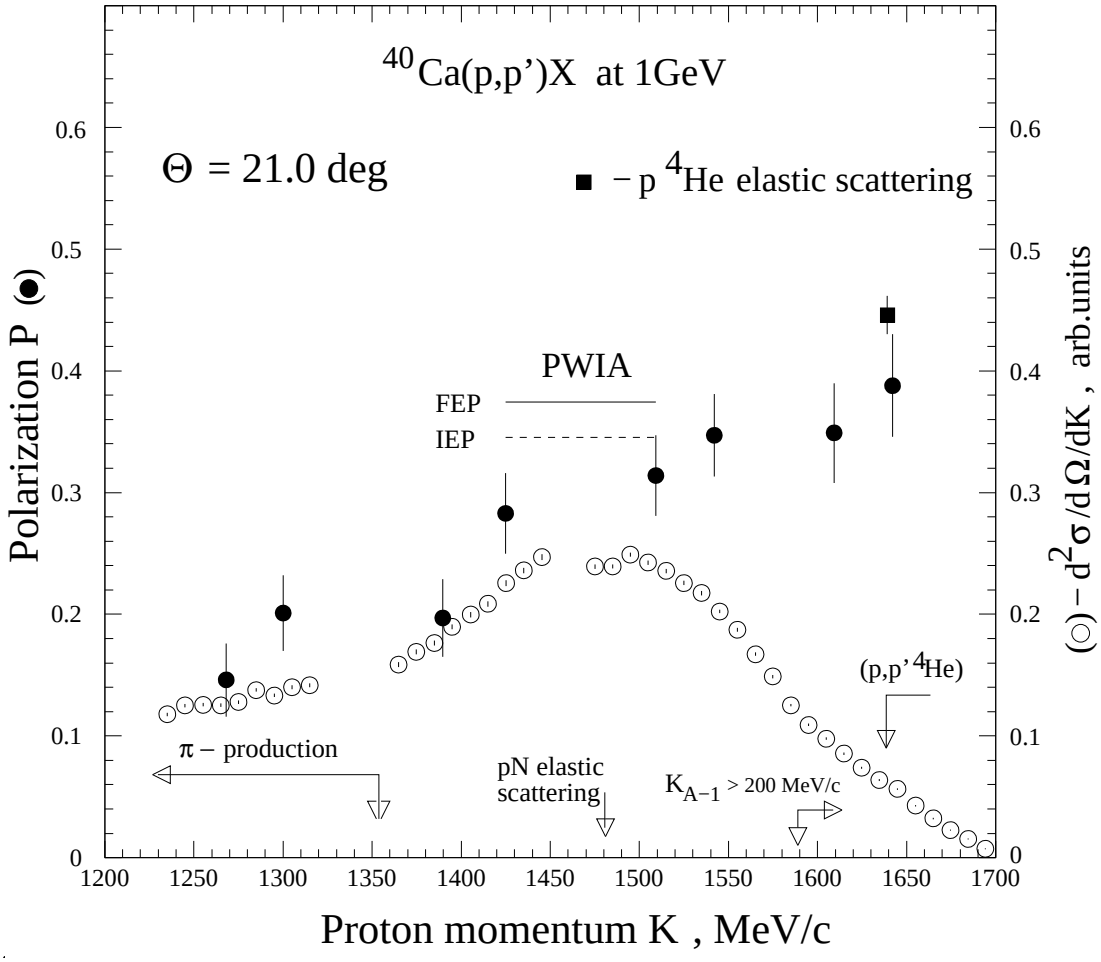

Figure 2: Polarization **P** of the protons scattered at angle $\Theta = 21.0^\circ$ (•) in the inclusive reaction ^{40}Ca$(p,p')X$ and the relative cross section of the reaction $\frac{d^2\sigma}{d\Omega d\mathbf{K}}$ - (○) as a function of the secondary proton momentum. Solid and dashed curves (straight lines) are the result of calculation in the PWIA using the final (FEP) and initial (IEP) energy prescription, respectively. The black square corresponds to the value of polarization in the elastic p^4He scattering [14].

4 Appendix:

TABLE 1: The polarization P of the scattered proton in the reaction ^{40}Ca(p,p')X at 1 GeV and lab. angle $\Theta = 13.5°$

K MeV/c	P	K MeV/c	P	K MeV/c	P
1267.1	0.135±0.030	1423.0	0.196±0.035	1623.1	0.317±0.043
1299.3	0.188±0.032	1511.1	0.327±0.034	1649.7	0.327±0.044
1387.3	0.155±0.034	1548.0	0.324±0.035		

TABLE 2: The polarization P of the scattered proton in the reaction ^{40}Ca(p,p')X at 1 GeV and lab. angle $\Theta = 21.0°$

K MeV/c	P	K MeV/c	P	K MeV/c	P
1268.0	0.146±0.030	1424.8	0.283±0.033	1609.2	0.349±0.041
1300.2	0.201±0.031	1509.3	0.314±0.033	1642.1	0.388±0.042
1389.7	0.197±0.032	1542.1	0.347±0.034		

TABLE 3: The relative cross section of the reaction ^{40}Ca(p,p')X at 1 GeV and lab. angle $\Theta = 13.5°$

K MeV/c	$\frac{d^2\sigma}{d\Omega dK}$ arb.units	K MeV/c	$\frac{d^2\sigma}{d\Omega dK}$ arb.units	K MeV/c	$\frac{d^2\sigma}{d\Omega dK}$ arb.units
1245.0	2499±26	1405.0	2111±24	1555.1	6546±65
1255.1	2439±25	1415.1	2152±24	1565.2	7106±68
1265.0	2476±25	1425.1	2158±25	1575.0	7403±69
1274.9	2449±25	1435.1	2200±25	1585.2	7839±89
1285.0	2603±25	1445.1	2291±26	1595.0	7887±89
1295.1	2452±25	1474.9	2490±46	1605.0	7887±89
1305.0	2446±25	1485.0	2702±42	1615.0	7935±89
1314.9	2407±25	1494.9	3048±42	1624.8	7356±86
1324.9	2369±25	1505.1	3420±47	1634.7	6979±84
1364.9	2101±24	1515.0	3876±50	1645.0	6388±80
1374.8	2127±25	1525.1	4563±55	1655.1	5602±75
1384.8	2098±24	1535.1	5163±58	1665.0	4981±71
1394.9	2117±24	1545.1	5782±61	1674.9	4911±70

TABLE 4: The relative cross section of the reaction ^{40}Ca(p,p')X at 1 GeV and angle $\Theta = 21.0°$

K MeV/c	$\frac{d^2\sigma}{d\Omega dK}$ arb.units	K MeV/c	$\frac{d^2\sigma}{d\Omega dK}$ arb.units	K MeV/c	$\frac{d^2\sigma}{d\Omega dK}$ arb.units
1235.1	1178 ±14	1415.1	2085 ±22	1574.9	1488 ±14
1245.0	1250 ±14	1425.1	2256 ±23	1585.1	1253 ±11
1255.1	1256 ±14	1435.2	2359 ±24	1595.0	1092 ±10
1265.0	1252 ±14	1445.2	2471 ±24	1604.9	978 ±10
1274.9	1278 ±14	1475.0	2392 ±18	1614.9	855 ±9
1285.0	1378 ±15	1485.0	2392 ±16	1624.8	741 ±8
1295.1	1334.±15	1494.8	2490 ±18	1634.7	639 ±8
1305.0	1401 ±15	1504.9	2424 ±18	1644.9	564 ±7
1314.9	1417 ±15	1514.9	2356 ±18	1654.9	428 ±6
1364.9	1586 ±19	1524.9	2258 ±17	1664.9	323 ±6
1374.8	1691 ±20	1535.0	2174 ±17	1674.7	227 ±5
1385.0	1763 ±20	1545.0	2024 ±16	1684.6	156 ±4
1395.0	1898 ±21	1554.9	1873 ±16	1694.2	73 ±3
1405.3	1997 ±22	1565.1	1672 ±15	1704.0	33 ±2

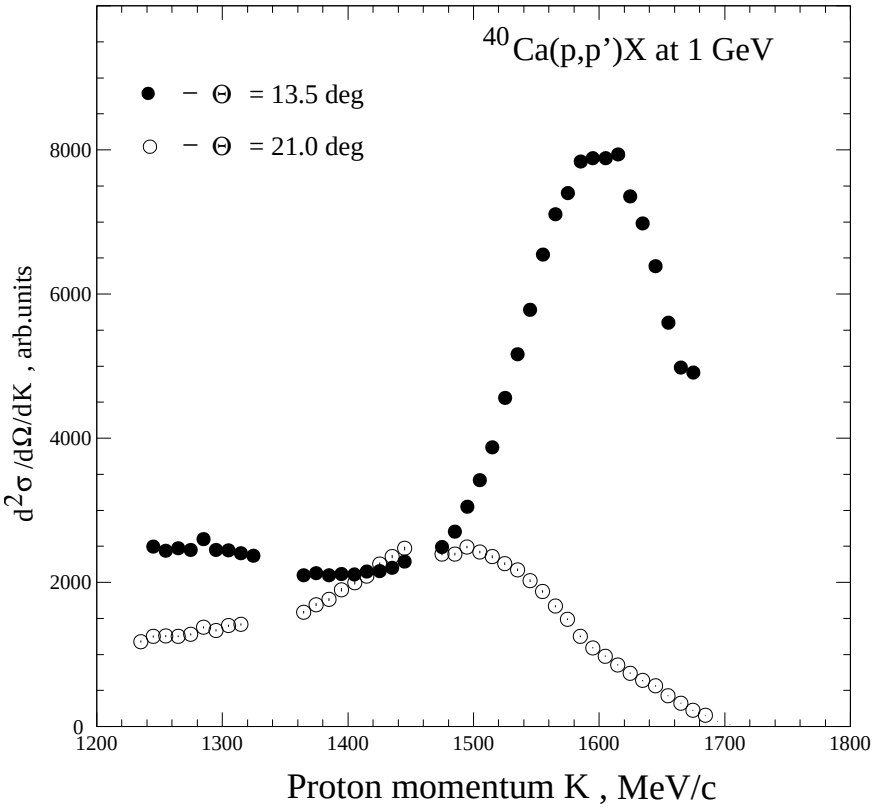

Figure 3: The relative cross section of the inclusive reaction ^{40}Ca(p,p')X at lab. angles $\Theta = 13.5^\circ$ and $\Theta = 21.0^\circ$ as a function of the scattered proton momentum $\mathbf{K}$.

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